TS200 A51 v.8

VOL. 8. JANUARY, 1900. No. 43.

THE JOURNAL

OF THE

American Foundrymen's Association.

Published Monthly by the Association at DETROIT, MICHIGAN.

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Price Per Annum. Single Copies, 20 Cents.

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ASSOCIATION.

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The American Foundrymen's Association is not responsible for any statement or opinion that may be advanced by any contributor to this Journal.

STANDARDIZED DRILLINGS.

The American Foundrymen's Association's Committee on Standardized Drillings desire to report that there are now nearly one hundred and fifty laboratories using its standards. As some of these use more of one sample than another, the committee desire to notify all who have purchased complete sets of three or four bottles, that they can now obtain separate bottles of samples, A, B, C, and D, for $2.00 each. There are quite a few laboratories that have not yet adopted these standards, and those who are interested in bringing about a greater uniformity of analyses, which these standards are helping to do, will please address any of the following members of the committee:

THOMAS D. WEST,
Chairman, Sharpsville, Pa.
DR. R. MOLDENKE,
Penna. Malleable Co., Pittsburg, Pa.
JAMES SCOTT,
Lucy Furnace, Pittsburg, Pa.
P. W. GATES,
Gates Iron Works, Chicago, Ill.
E. H. PUTNAM,
Moline Plow Co., Moline, Ill.

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A REVIEW OF THE FOUNDRY LITERATURE OF THE MONTH.

IRON AGE.

In its issue of December 28, this journal says:

Some interesting developments have taken place in recent years in the manufacture of articles of complex shapes. There was for a while a striking substitution of small castings by shaped sheet steel. It looked as though the press would capture a large part of the outlet for castings, gray and malleable, in a number of branches of the manufacture of small wares. In the meantime, however, really remarkable progress was being made in producing sound finished small iron and metal castings. Yet in spite of this no single year has witnessed so great a development in the number and capacity of plants manufacturing malleable castings. Almost coincident with this we have the spectacle of an enormous pressure on those works which produce steel castings, large and small, followed by a perfect rush into the business. During the past six months a large number of new and important concerns have entered the business, or are preparing to go into it.

THE TRADESMAN.

Under the title "How to Make a Baby Cupola at a Small Expense," E. H. Putnam writes:

It frequently happens that a foundryman wishes he had a small cupola for some special work, and the only reason that he does not make one is that he has an idea that the expense will outweigh the convenience. It is customary to make these cupolas of wrought iron, supporting them on trunnions, on a specially constructed frame, so that the cupola can be turned bottom end up if desired, for the greater convenience of fettling; i. e., cleaning and making ready. This cupola is also provided with a drop bottom. The height is limited to convenience for

charging in at the top. A disconnected stack is provided, with a widely-flaring bottom section which telescopes freely with the stationary section which extends through an iron collar in the shop roof. These cupolas are generally made very small, in order that they may be easily tilted. But here is an easy, cheap way to make a fairly good-sized "baby" cupola; one that can melt a ton heat without any trouble: Just take a pulley-ring pattern and cast from it three or four rings, drawing it up to get the desired depth. Rivet some inverted U-shaped lugs on two opposite sides of each ring, through which to thrust bars for lifting. Line each ring separately with fire-brick. Set the first ring on the cast iron bottom. After luting with fire-clay, lute the joint and set on the next ring; and so on to the end. The cast bottom may be a square casting one inch thick, with a hole for the drop door. The latter need not be hinged; but make it with a flange all around, and prop it in place in the usual way. The tuyeres should be made of cast iron, and the same general plan as in the case of a large cupola. The stack is the same as described above. Bolt four cast iron legs to bottom plate. This cupola is very simple, and can be made "for a song." I recommend the use of a 36-inch pulley-ring for pattern; any smaller is too trifling.

The same writer in a previous issue referred to the possibility of making malleable and gray iron castings in the same shop, and we reproduce some questions pertaining to the subject and Mr. Putnam's answers thereto:

"Do you know of any gray iron foundry plant that is making malleable castings in the same cupola from which it makes its common gray iron castings? If so, is not a different quality of pig iron used, and a different mixture from that used for gray iron? What then would be done with the sprue and over-iron that is left from the malleable heat? We use about 250 tons of malleables per year, and if the plan you suggest is practicable there is no good reason why we should not make our own malleables."

"1. I do not know of any foundry making gray iron and malleable castings from the same cupola at present. But, for

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a period of five years, namely, from about 1884 to 1889, I manufactured chilled plow castings, agricultural machinery and malleable iron castings, all from the same cupola and at one and the same heat. In doing this I found no difficulty in separating the gray iron from the malleable iron. As a complete separation of the two mixtures is necessary, I will explain how this is accomplished, the more gladly as it is a rule of practice that will apply to many similar situations.

"Malleable iron castings are packed in heavy iron pots before going into the annealing oven. These pots should be made of very hard iron, though not so hard as is required for heavy malleable castings. It takes a good many of them to begin with, and they burn out, and must be replaced. The iron that is tapped from the cupola after the malleables are all poured, and before the gray iron begins to come down, may be poured into these pots. If, now, all the hard iron is not out, pour it into pig molds. Draw the iron from the cupola as fast as it melts at this juncture, so as to be sure of draining out practically all of the malleable mixture before the gray iron mixture begins to come down. But now the question suggested to your mind is, 'How do you check the melting process at this point so as to insure the melting of the malleable iron without also melting the succeeding charge of gray iron?' It is as simple as standing an egg on end. Iron will not melt in the cupola above a certain point upward from the tuyeres; and, above another point somewhat less removed, it melts very slowly; therefore, when you wish to separate two widely different mixtures of iron in the cupola, put twice (or more) the usual charge of coke between them. Of course, this necessitates the burning up of extra coke to the amount of one or two hundred pounds; but that is a mere bagatelle as compared with the running of a separate cupola.

"Much greater exactitude is required in malleable mixtures than for gray iron; therefore melt the former first, so as to be sure of its being right. Remember, also, that, though hard iron is said to melt with less heat, it takes a much greater initial heat to make it sufficiently fluid for casting purposes. I would advise,

for a starter, 50 per cent more fuel for malleable than for gray iron. I think this would be too much; but too much is immensely better than too little, as in the latter case you could not use the iron at all.

"2. Yes, a very different iron mixture is used in malleable iron. Gray iron castings must be soft; but malleables must be much softer, and ductile also. This is accomplished by several chemical operations. First, in the mixture, in conjunction with the operation of casting, the carbon is chemically combined with the iron. The physical evidence of this state is in a wholly white fracture. Then the annealing process affects the carbon in perhaps several ways. It may be that the oxygen of the 'packing' enters the heated iron, unites with some of the carbon and escapes with it in the shape of a gas. Perhaps, also, it changes the character of the carbon that remains in the casting. There is a difference of opinion here. But neither you nor I need care a flip about this. It is enough for us that we know that the carbon must be wholly combined with the iron in the casting, or else the annealing process will leave the casting all honeycombed and 'rotten.' Do not use any foundry iron in making malleables. Though coke iron pretty well down to the Bessemer limit is used in making air furnace malleables, I do not now know whether this would answer in the cupola or not, but I shall probably be able to answer this question before long. About the equivalent of No. 5 charcoal iron is right for light malleables.

"3. The sprues, scrap and over-iron are used in the next day's mixture. For this reason you cannot use all No. 5 iron, but you will probably make up a mixture from Nos. 2, 5 and sprue.

"As the manufacture of malleable iron is expanding very rapidly, and has already become one of the most important features of the iron industry, I shall be glad to answer any further queries from any of our readers concerning the business, the more so since there is said to be but one malleable foundry in the whole South, though the South consumes enough to employ half a dozen big ones."

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AMERICAN MACHINIST.

Referring to the subject of chemical analyses, a contributor writes as follows:

It was not so long ago that a furnace representative claimed that by the analysis test he was able to duplicate an iron that had been found satisfactory by us. As his offer was attractive, he was given some borings of the iron, together with an order for a trial lot, which he seemed to prefer sending, making it appear that he had not the utmost confidence in his ability to carry out his representations. Suffice it to say that the trial lot came in due time; but when tried did not prove to be equal to the iron he attempted to duplicate. The first trial was sufficient, for he "threw up his hands," and the conditional order for a large block was canceled, and another order was placed with the old furnace, which was not so enthusiastic on the subject of chemical analysis, but which could make iron that suited.

At the time of taking the borings referred to, in response to an offer to analyze another iron, borings of this also were furnished. I was afterwards given the analyses of both irons, which I will designate as A and B, and the following figures were those submitted:

	A.	B.
Graph. Carbon	3.04	3.26
Comb. Carbon	.54	.29
Silicon	1.66	3.10
Phosphorus	.57	.22
Sulphur	.019	.032
Manganese	.84	.66

As the irons were used for making the very lightest of castings, you can imagine the trouble that would have resulted had the A iron been true to the analysis, with its .54 of combined carbon. It would have been so hard that it could not have been used while in reality it is one of the softest and most expensive irons on the market to-day.

About the same time another furnace analyzed the same irons with results below stated:

	A.	B.
Graph. Carbon	3.74	3.80
Comb. Carbon	.05	.24
Silicon	2.65	3.20
Phosphorus	.556	.76
Sulphur	.016	.042
Manganese	.32	.60

You will note the difference between the two records, which tends ot show that even the analysis test is at times unreliable. One of your former correspondents admits that there is often a difference of 1½ per cent of silicon in the same cast and grade of iron. If this is a fact, what would an analysis, as conducted at present, show but an average of the entire cast? Unless different portions of the cast are separated and distinct analyses of each are taken I do not see that one test is much more accurate than the other.

I have heard of some manufacturers located in the iron making region taking iron from the furnace and working it up before it had a chance to cool; but I think this practice would be impracticable for a manufacturer doing business in New England. It appears as if the furnaces had a difficult job on hand to undertake furnishing sandless pig iron, especially where it is required to be very soft. If metal molds were used I should expect the iron to be chilled, and the foundryman getting such iron to have a similar experience to that which he would obtain from a lot of chilled plow castings, the use of which is invariably avoided where soft castings are sought for.

The analysis test and sandless pig iron may come into use some day and be a benefit; and I will be as thankful as anyone to have that time come, for I have had practical experiences with the present methods, some of which have not been the most satisfactory.

To the issue of December 28 Thos. D. West contributes an article on "Sandless Pig Iron," which we reproduce in full:

The sand adhering to pigs cast in sand molds can cause much trouble by creating slag, "dirty iron," decreasing the speed of

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melting and assisting to "bung up" a cupola. Many founders knowing these evils go so far as to tumble their gates, besides being particular to use as clean pig and scrap iron as they can obtain.

The sand scale which forms on pigs cast in sand molds may range from 50 to 150 pounds per ton, according to the grade of sand used and the heat of the metal at the time the pigs were cast. This is best seen by founders who can take pig iron as it comes on buggies direct from the furnace casting house, or those requiring but short delieveries by railroad cars. The throwing of sand pig into cars and the shaking it receives by long hauls does not permit the founder to see so well the amount of worthless sand or material he is paying freight on and, in one way, pig iron prices for, as it is to be remembered that cars are weighed empty before any iron is loaded into them. Founders having long hauls will not have the sand scales to contend with, when the pig iron reaches the cupola staging, like those getting it on buggies or from short deliveries. Nevertheless, there is sufficient sand scale at its best adhering to new pig iron, hauled long distances, to make it in every way desirable for all founders to have a "sandless pig."

When efforts were first made to introduce "sandless" or chilled pig iron, it met with opposition on the ground that such pig would give makers of stove plate, light machinery or any soft castings, trouble in the way of hard iron in their castings. This came of the old belief among founders that an iron once chilled could not be returned to a gray iron by remelting, or that an iron once chilled would be sure to give a harder iron when remelted, than had the iron never been chilled. This belief was so strong among all founders, and is to-day with many, that in selecting scrap iron, they will pick out the chilled parts of car wheels, plow points, etc., to set it aside from the gary body of such castings, when desiring to make soft mixtures, for fear it would make their castings too hard.

For many years I followed this same practice, because taught to do so by those before me. A study of the question could give

me no good reason for this, and being unable to find anyone that could do so, I finally decided to experiment, to find out if the practice was correct. This I finally did a little over a year ago, in an elaborate series of experiments, by means of a twin shaft cupola and rolls 2½ inches diameter by 6 inches long, that had been cast from the same ladle into chill and sand molds. An account of this work, which was assisted by Dr. R. Moldenke in making analyses, was given to the Pittsburgh Foundrymen's Association and published in full by the American Foundrymen's Association Journal, Vol. III., No. 17.

The results of these experiments were a surprise to others as well as to the writer. The experiments proved that past practice in this line was incorrect, as it was found that by the remelting of any castings having part chilled and part gray iron, as in car wheels or plow points, the gray part of such casting would really give a harder iron than that which came from the chilled parts. This was demonstrated by the remelt of chilled rolls drilling easier, and their analyses showing higher silicon, lower sulphur, with higher graphitic carbon than the remelt of the gray rolls. Why we should expect these results is due to the well-known fact that hard or chilled grades of iron will melt faster than soft or gray bodies. The faster melting of the hard or chilled iron, as compared with the softer or gray iron, and its greater density, caused the former to have less silicon burned out and sulphur absorbed, thereby causing higher graphitic carbon in the chill remelts, which would make it the softer iron.

Just as this article was about to be mailed, I noticed in a recent number of the American Machinist a paragraph which will show how firmly founders believed that chilled iron remelts will give the harder iron.

I had no sooner discovered and announced the fact of chilled iron to be favorable in giving the softer product, than the claim was made by a well-known furnace salesman at a foundrymen's meeting that a greater loss would be incurred by oxidation in the melting of chilled or "sandless pig" than by that having sand

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scale in it, which was said to afford protection to the iron against oxidation or being burned away while being brought to a liquid state. Wondering if this was really true, I concluded to experiment, and in a very short time discovered that the claim was erroneous, as there was, if anything, less loss in melting chilled or "sandless" irons than those that might be protected by a coating of sand or other foreign material. This was proved by an extensive series of heats, an account of which was given in a paper by the writer to the Pittsburgh Foundrymen's Association, and published in the society's Journal, Vol. IV., No. 20.

Among the advantages so far found, "sandless pig" may be said to offer the following: First, in being an iron which melts faster; second, in affording the softest remelts; third, in requiring less flux to make a good slag; fourth, in giving a cleaner iron; fifth, requiring less fuel; sixth, in giving an iron which loses as little if not less than sand pig by oxidation. To these can be added the seventh, and which may be termed a greater uniformity of the metalloids, caused by the liquid iron at the furnace being caught in a ladle before being poured into the pig molds, which act as a mixer. The importance of this factor will be understood when we stop to realize what it means to find one end of a cast of pig iron run into sand molds after the old fashion, to be 1 per cent higher in silicon than the other, something which is liable to happen at any time in operating a blast furnace. The two ends of a "cast" poured from a ladle would be very closely alike in their silicon, etc., contents; so that if in shipping iron each ladle's pouring was kept by itself, after the manner each furnace "cast" is generally piled or shipped, foundrymen would find a much greater uniformity in the grade of iron coming from their cupolas than is generally done by using pigs cast in sand beds.

It has been calimed that the fracture of sandless pig can be accepted as a true guide to judge its grade, or what percentage of silicon and sulphur a "cast" or piece of pig metal may contain. To what extent this is true I am not now prepared to say. However, there is this much that can be said: A "cast" poured from

a ladle is bound to be more uniform in its grain than one run in sand pigs. It is also to be understood that because "sandless pig" is sometimes called "chilled pig," it does not follow that the sandless pig is always really chilled or shows any white fracture. This may be so with iron very low in silicon or high in sulphur. With iron above 1 per cent in silicon and not having over .04 in sulphur, we may, as a rule, expect the outer body of the sandless pigs or that lining the iron mold to be little affected by chill, so that with the sandless pigs suitable for making gray castings, their fracture would look gray throughout the body, with little or no indications of having any "chill."

The adoption of casting tables for making sandless pig was at their introduction rather slow, but in talking the other day with a manufacturer of casting tables, I was told that he had to refuse orders on account of having more now than he could fill for a long time to come. I find upon investigation that the following firms are at the present time making sandless pig, and in a few months several others will be doing likewise: Carnegie Steel Company, Oliver & Snyder Steel Company, Laughlin & Co., Shenango Valley Steel Company, Riverside Iron Works, Lebanon Furnaces, Struthers Furnace Company, National Tube Works, American Steel & Wire Company, Bellaire Steel Company and Canal Dover Furnace.

One drawback which may be said to exist in the adoption of sandless pig consists in the present form of pig molds, giving a pig that is rather clumsy for foundrymen to handle. If inventors of casting tables, or furnacemen seeking foundry trade would try to make their sandless pigs of a size corresponding to the sand pigs foundrymen have been accustomed to use, I believe there is not one but what would be glad to give sandless pig a trial, and ever after be desirous to continue its use.

I am pleased to say that information has come to me since mailing this article, that one of the manufacturers of casting tables has experiments now being made with molds to give a pig about 75 pounds in weight, to take the place of the larger pig now being used, and which is so objectionable to founders.

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Knowing that Mr. Edgar S. Cook, the well-known blast furnace expert and president of the Warwick Iron Company, Pottstown, Pa., had experimented with making sandless pig to have founders test it before he would place casting tables in his blast furnace, I wrote him asking for his experience, and received a reply, from which the following extracts are made:

"We have not yet adopted a casting table, but we propose doing so, and will doubtless have one in operation some time next year. A few months ago we ran a lot of foundry iron into cast iron molds such as are used in the manufacture of basic iron. This iron was selected by analysis and sample carloads furnished to our various customers, care being taken that the 'sandless' pig should be of practically the same silicon and sulphur contents as the sand pig that we had been accustomed to send them. In regard to the composition of sandless pig, so far as silicon and sulphur are conerned, there is no reason why the sandless, after a little experience, cannot be judged far more accurately by fracture, as to the composition, than is the case with iron cast in sand. Of course, the ability to make a fairly good guess will be dependent upon the experience of the observer and after comparing the fracture of the sandless pig with many analyses. I enclose herewith copies of letters from parties, which speak for themselves."

From the letters Mr. Cook sends, the writer takes the following extracts:

From a prominent tool-building concern: "We have tried the sandless iron and find it very nice. You may ship more on our orders."

From a stove foundry: "From the experience we have had we believe, thus far, that you can be sure that there is one foundryman who does not fear the sandless pig."

From the foundry superintendent of a large ship and engine building establishment: "I am pleased to say that your sandless pig is very satisfactory. I hope hereafter that you will always ship me sandless pig. It saves a good bit of trouble in the cupola. I think you are making a move in the right direction."

From Girard Iron Works: "We are using the sandless pig iron and have had, so far, very good results from it."

From Lebanon Stove Works: "We have watched the results very carefully thus far and find it very satisfactory. The only objection we have to the sandless iron is that the pigs are too heavy and too hard to break. Our cupola men can hardly handle them, as our facilities are such that the short, heavy pigs of the sandless iron cannot be broken; otherwise, we are very much pleased with it."

I hope this article will afford your readers a good knowledge of the utility, progress and adoption of sandless pig. I would not have gone to the labor of writing or working in the past for its introduction, did I not believe sandless pig to have many advantages to the founder, and that it will not be long until most all furnaces will be making sandless pig.

THE FOUNDRY.

Writing on the "Shrinkage of Brass Castings," P. Longmuir says:

Firstly, the vertical is not the correct position for casting brass or indeed any alloy liable to "segregate." The writer recalls experiences of shaft liners up to 30 feet in length. In these cases the horizontal, or only a little inclination, gave results far surpassing the vertical position of casting. Propeller blades are another instance—the horizontal position being adopted in all cases when cast of gun metal or brass. Manganese bronze is, however, an exception; the vertical position does give better results with this alloy.

Another feature of interest is that gun metal test bars cast in the horizontal position give better tensile and elongation results than do those cast in the vertical position.

The shrinkage or "draw" of brass is more or less a question of temperature and judgment. With proper manipulation of metal, disposition of gates, arrangement of casting position and correct judgment as to casting heat, almost any weight of gun

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metal can be cast with little or no need for a feeding rod. The writer has in mind propeller hubs and similar castings of about five tons in weight, which turned out as solid as could be desired, and that without the aid of a feeding rod. But it is more or less a question of temperature. Dull metal is apt to draw into cavities in which sometimes may be seen a button, high in tin, and which has the appearance of having oozed through after the main body of metal had set and the cavity formed.

In addition to these cavities, "cracks" are often found with gun metal cast at a dull heat. These are seen to best advantage at the junction of thick and thin metal in the corners of a casting, or if there be a flange, round the junction of flange and body. These cold cracks are a source of trouble to the brass founder. They are at times so fine as to only show when tested hydraulically, and at other times will be one-eighth-inch in breadth, almost severing the casting.

Castings with these faults when remelted and cast at the proper temperature come out right.

One point may be added before leaving this subject. In casting brass the mold should be quickly filled; otherwise flakes of zinc oxide gather on the top of the rising metal and are in effect equal to dirt, forming dross and giving a dirty casting.

With regard to copper castings, swelling would be due, not to excessive temperature, but rather to the absorption of oxygen. Sound copper castings give a contraction of about 7-32 inch per foot. The difficulty is to get a contraction at all. The expansion or non-contraction of copper castings may be due to the gases absorbed during melting being liberated on solidification.

In "Cast Iron Notes" W. J. Keep takes up the phenomenon of "stratified" cast iron in reply to the following communication addressed to him:

"Dear Sir:—Last winter a foreman of a foundry told me that about twenty years ago he tried to use a pig iron that absolutely refused to mix with other irons, and there would be distinct layers. I regarded this at the time largely as a myth, but about a week ago I was up in the country and ran across a case up

there which confirms me in the belief that there is something in it. I have seen in my time a good many kinds of iron. I have seen iron white in the light portion and gray in the heavier portions, but I have yet to see iron white in the center and gray on both sides. I enclose you a sample of this, and should like to have your theory as to the cause thereof in your 'Cast Iron Notes.' Some of the pieces that I saw up there had a good deal more gray iron and less white iron than the piece inclosed herewith. It might be interesting to have the analysis of this if it could be obtained. I do not know that an illustration could be made thereof, but if it could I am sure it would interest your readers."

Answer.—This specimen is very interesting to anyone in the foundry business, and is especially so in its bearing upon the question whether chemical analysis will explain the physical quality of cast iron. Fig. 2 is a drawing the exact size of the specimen sent to me. It will be noticed that the casting is 5-32 of an inch thick and is composed of three layers of equal thickness. The middle layer is perfectly white and hard, while both of the outside layers are dark gray and are soft. A drill will enter the soft outside, but cannot penetrate the center. It is not the hardness of chilled iron, but is a slippery hardness, and the drill polishes the surface, but the white portion is exceedingly brittle.

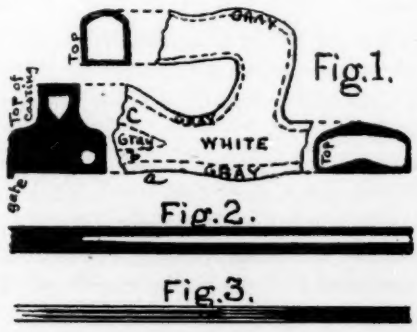

Figure 1 shows the appearance of three fractures, a single casting, all being of natural size. The gate of casting (a) is

marked on one of the sections. There is a white streak surrounded by gray at b, a larger streak at c. The white at the other two fractures is nearly the full size of the section, but is entirely surrounded by a gray exterior.

This phenomena may be new to many readers of The Foundry, but I think some could furnish more remarkable specimens than these. I have from time to time had quite a number sent to me. There was no similarity of chemical composition whatever.

Should anyone wish to see drawings of some wonderful specimens of this stratification they can find them on pages 615 to 620 of Tranactions Am. Institute of Mining Engineers, 1893. I gave drawings of the fractures of several pigs of iron that I found in the Swedish exhibit at the World's Fair at Chicago, and of a large number of samples which I had collected. I gave an illustration of a fracture very like Fig. 1, and gave the analysis of both the gray and the white part, as follows:

	Gray Part.	White Part.
Total Carbon	3,628	3,861
Graphite Carbon	1,874	1,307
Combined Carbon	1,754	2,554
Silicon	2,846	2,742
Manganese	....	0,501

This shows that the silicon is practically uniform throughout the casting and that at certain temperatures the carbon will take the combined form independently of either temperature or of silicon content.

It also shows what the chemists claim, that the fracture (or physical quality) in many cases does not indicate the chemical composition. Will you allow me to make the same statement in the way I believe the founder should remember it, viz.: The chemical analysis of an iron will not indicate its physical quality, and nothing will except a physical test. In the above sample the total carbon is essentially the same in both gray and white parts, and the variation in figures may be due to an error of the chemist. There must be more combined carbon in the intensely white

center, but it is remarkable that one-half as much graphite was hidden from view in the white part.

The amount of combined carbon in both parts is very large in the presence of 2.80 silicon. At one time I took fifteen pounds of the perfectly white portions of castings which had in other portions white centers and gray exteriors, and melted them in a crucible. The resultant castings were an even gray, with no indication of white. The color of the gray part was light, indicating considerable combined carbon.

Before a further discussion of this question I am going to give a drawing (Fig. 3) of another casting, which I found in our foundry about a year ago. The edge started 3-32 in thick, and for ¼-inch wide the casting was all white; then the casting is but ¼-inch thick, and at once separates into seven distinct layers. Under a strong glass the surfaces are distinctly gray. Next are two white layers, next two gray, and at the center a white layer. Under the glass each of the seven layers seems about the same thickness, and at one part there are nine layers. This is the most remarkable example of stratification that I have ever seen. The drawing is exact size.

In the latter case there had been no change in the iron mixture. The silicon was near 3.00 per cent. This was the only casting found in a heat of seventy tons. Such castings generally break in the tumbling barrels and are brought to me. For five years I made a standing offer of ten dollars to any molder who would at any time give me previous notice and then let me see him produce a casting gray on the outside and white at center, but every trial ended in failure. One day I told a molder near the cupola to make for me two flasks of test bars and pour them as soon as possible. They came out white at center and gray on the outside. I asked him how he did it, or rather, what he did out of common, and he didn't remember anything. I had him try again and he failed, but the third time he succeeded. We found that he held his ladle (which had never had molten iron in its lining) for the iron that another molder had caught from the cupola in another just such a ladle, and this iron was one of the

first three or four ladles that came down. The iron had boiled on the new cupola bottom and had boiled in two fresh ladles. Iron caught in two such ladles after eight or ten ladles had been taken or the first iron caught in one ladle would not produce the phenomenon, and sometimes for months no combination would produce it.

This is a peculiar specific condition attending melting that produced very remarkable results irrespective of chemical composition. Just a slight variation in the proportion of the irons in the mixture would make it impossible to produce these castings. Yet if no change was made, there have been times when the number of such castings would increase.

This is not due to the irons composing the mixture not mixing, but is due to a peculiar condition of the melted iron. On entering the mold the cold surface of the mold brought the temperature of the molten iron to such a point that as it became solid it was gray. The temperature then changed to cause the next iron to set white, and then the next to set gray, and then the remainder in a very few seconds, if not in less than one second. The physical manipulation of melted iron and the conditions under which it cools, whether slow or fast, exert so much greater influence upon the physical quality of the final casting, that a chemist by analysis does not find enough conformity between chemical composition and physical quality to allow a determination of definite relations between them. But the founder can determine the physical condition by physical tests and can tell whether an increase or decrease of silicon would improve it.